FTD-TT- 63-322

409 008

TRANSLATION

OBSERVATION OF DISLOCATION STRUCTURES IN THE ALLOY KhN77TYuR

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FTD-TT- 63-322/1+2+4

UNEDITED ROUGH DRAFT TRANSLATION

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English Pages: 7

SOURCE: Russian Periodical, Metallovedeniye i Termicheskaya Obrabotka Metallov, Nr. 9, September 1962, pp. 2-5

SOV/129-62-0-9

FTD-TT- 63-322/1+2+4 Date 17 May 19 63

OBSERVATION OF DISLOCATION STRUCTURES IN THE ALLOY KhN77TYuR

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In recent years there has been increasing interest in the study of dislocations as a special type of crystal structure defect, which is of great importance for almost all phenomena whose investigation is the problem of the physics of metal: crystallization, plastic flow, recrystallization, and phase transformations in the solid state. The dislocation structure substantially influences the strength of metals and alloys.

Therefore, direct and indirect methods of experimental study of the structure of metals are of great interest. As we know, direct electron-microscopic observation of dislocation is presently possible on crystals of a certain substance with unusually large interplanar spacing (J. W. Menter [1]).

Dislocation lines are directly observed in metals by the electron microscope, however only on thin films transparent for an electron beam [2].

To study the dislocation structure within crystals, we use only indirect methods of observing the outcrop of dislocation lines at the surface of crystals based on etch pits [3], and similar methods of revealing dislocation lines by staining them with the solid-solution precipitation phases. Sometimes only one segregation of impurities near dislocations enhances the tendency of etch pits to form [3]; in other cases particles of a new phase are formed near dislocations.

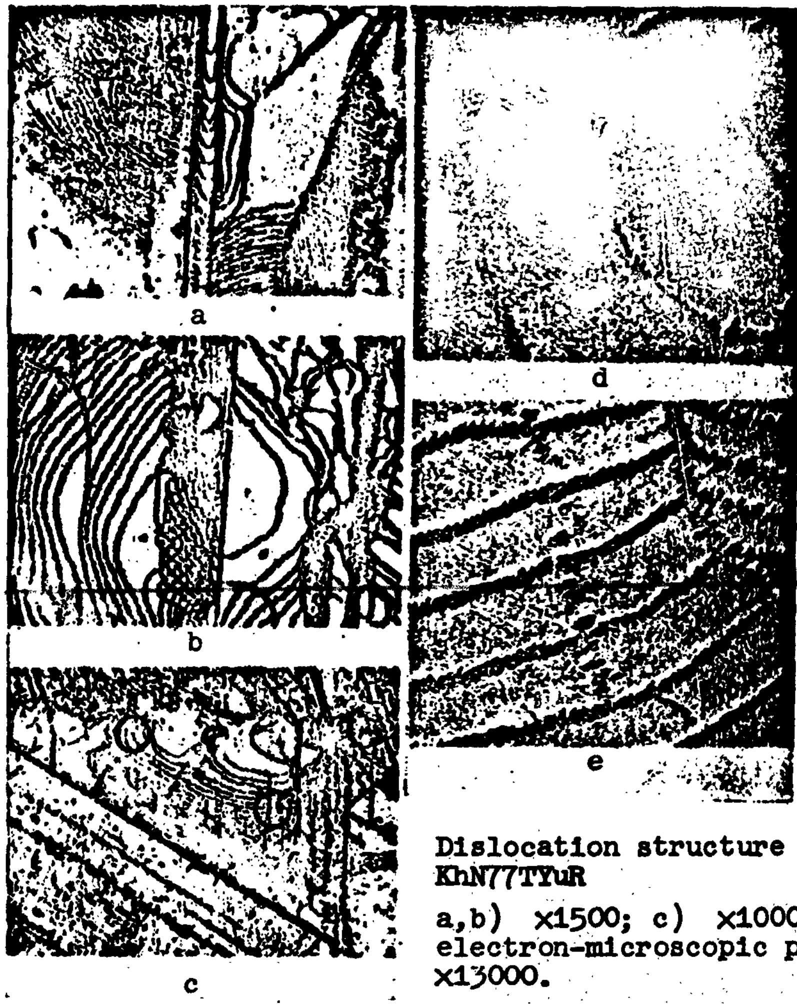
In this article* we will describe our observations of dislocation structures in the alloy KhN77TYuR by means of elementary metallographic methods.

Samples of this alloy measuring 15 × 15 × 15 mm were twice water-quenched at 1200 and 1180° with subsequent aging at 750° for 16 hours. The microsections were etched in a reagent of the following composition: 4g of $CuSo^4$, 20 cm^3 of HCl, and 20 cm^3 of water for 15-20 min without mixing.

During the examination of microsections it was observed that certain grains in the individual specimens have a sharply distinctive structure: they are more weakly etched, the excess phase precipitating from the solid solution forms a chain arranged in the form of a complex system of loops whose individual elements sometimes form a rather accurate geometric design (Figs. a-h)**.

* The experimental part of the articles was done by A. F. Kartasheva.

** The sections were examined and photographed at X550 with subsequent photographic enlargement to the values shown in the figure.



Dislocation structure of Alloy KhN77TYuR

a,b) ×1500; c) ×1000; d,e) an electron-microscopic photograph ×13000.

Obviously, the grains in which such a structure is revealed are different in that for them the octahedron surface (L11) is arranged parallel to the section surface: we are able to judge this by the size of the angle (60°) between the mutually intersecting slip marks (Fig. e) and also by the shape of the etch figures which are equilateral triangles (see Fig. 3). Of course, such a congruence of surface (111) with the microsection surface was accidental, with relatively small precision.

We can consider that Figs. a-h represent the arrangement of dislocation loops on the slip plane fixed by the aging-phase precipitations. In this case, the movement of dislocation lines was evidently associated with the effect of quenching stresses. Local stresses σ are calculated by the formula

$$\sigma = \frac{Gb}{R},$$

where G is the modulus of rigidity; b is Burgers vector equal to $\frac{\sqrt{2}}{2}a_0$, a_0 is the parameter of the lattice; R is the radius of curvature of the dislocation loops.

Calculation by the formula gives $\frac{\sigma}{G} \approx 10^{-4}$, which corresponds to the value of critical shear stress.

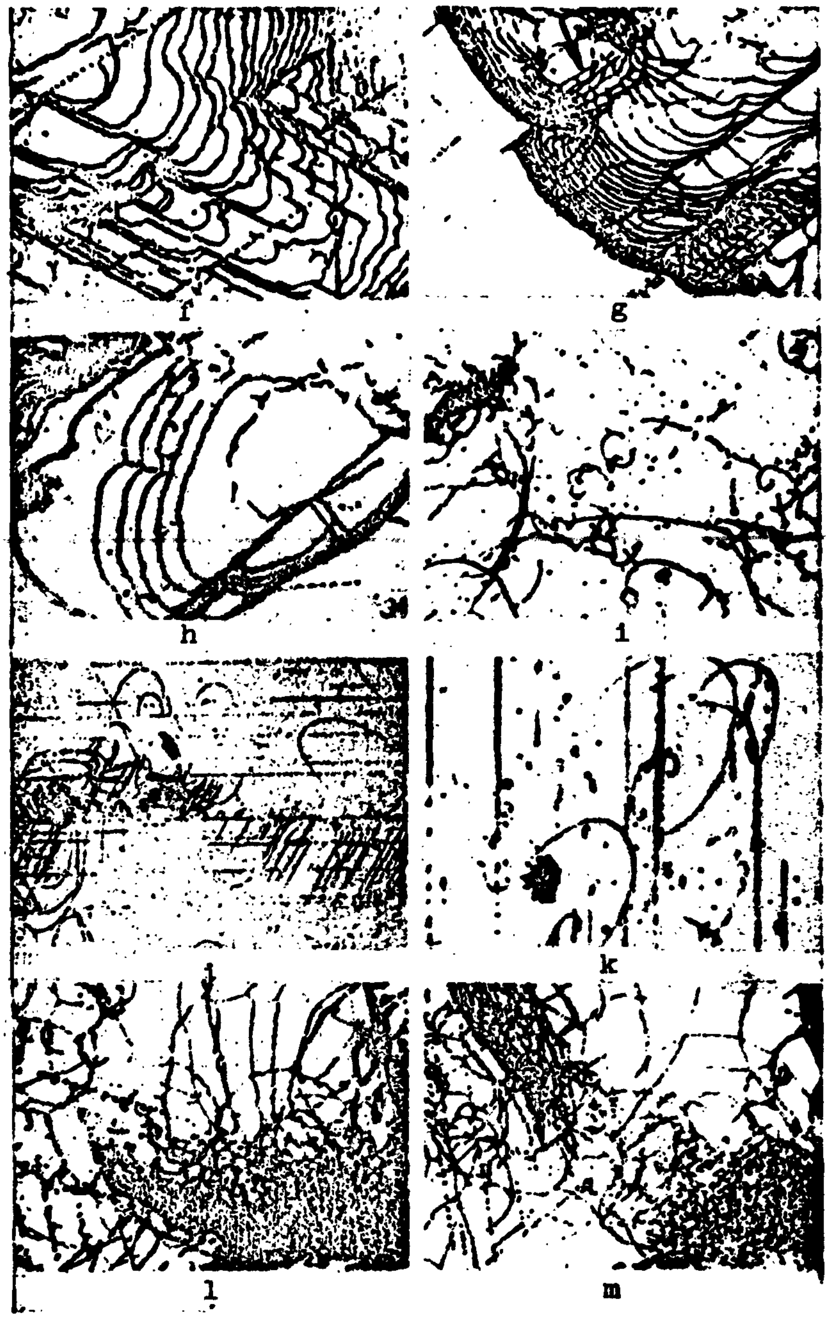
A system of loops such as that in Figs. a-h evidently depicts the microscopic structure of the slip mark "in plane", whereas the rows of points along the lines intersecting at an angle of 60° (Figs. f, j, k) represent "a cross section" of this group of dislocation loops.

In the photomicrograph it is very obvious how the dislocation loops accumulate in front of obstacles "in plane"; we can also see accumulations of dislocations in front of the obstacle in "cross-section" — as a gradual sealing of the dotted points.

The occasionally observed superposition of two systems of loops, expanding as if independent of each other (Fig. 6), can be explained by the fact that the staining by the precipitation phase can simultaneously reveal dislocation lines arranged in different (parallel) slip planes. Together with this, in certain places the intersecting dislocations form cells of a single network (Fig. g, arrow).

In a number of cases, we can observe Frank-Read sources from which the dislocation loops (Figs. i-k) are formed. Not always is the finished form of a source easily explained by the not completely accurate paral-

lelism of surface (111) with the surface of the section.



a-h) ×1500; i) ×1200; j) ×500; k) ×850; l) ×1200; m) is the same as Fig. l after repolishing. ×13000

As could be expected, dislocation structures observed "in plane" are purely surface structures; with the slightest repolishing of the microsection they disappear and are replaced by new ones (Figs. 1-m).

Consequently, decomposition of the solid solution during aging of alloy KhN77TYuR is localized at the dislocation lines (and, of course, at the edges of the grains), whereas the bodies with more perfect lattice situated between them, are found to be free from precipitations of the excess phase. Thus, once more we emphasize the significance of defects on crvstal structures in the kinetics of phase transformation and formation of alloy structures.

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